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FOR IMMEDIATE RELEASE

NEW STUDY FINDS NO SIGNIFICANT HEALTH RISKS FROM LEAD CONCENTRATES ON HAUL ROADS

ST. LOUIS, May 13, 2002 - An independent health risk assessment concludes that lead concentrate levels along the roads in Herculaneum used to transport lead to the smelter pose no significant health risks to children or adults in the community. The new scientific study also establishes objective criteria for establishing acceptable lead levels along the streets to protect human health, and it supports the removal of signs prohibiting pedestrian use of streets and sidewalks along these roads in Herculaneum.

The study is the first scientific research to quantify the level of risk posed by lead ore concentrate on the roads, and was prepared by Teresa Bowers, Ph.D., one of the nation's leading authorities in lead exposure modeling, risk assessment, and soil cleanup levels. Dr. Bowers, a lead risk assessment expert with Gradient Corporation of Cambridge, Mass., has authored more than 30 journal articles, and is the author of an adult lead model now being used by the EPA.

Dr. Bowers prepared the study at the request of Doe Run in response to reports of elevated levels of lead found in street dust samples collected in August 2001, in Herculaneum. This new scientific study of haul roads in Herculaneum concludes that:

- Exposure to lead ore concentrate in street dust currently measured is not expected to have any significant or lasting effect on blood lead levels for children or adults; and
- A one-time exposure to an unusually high concentration of lead is not expected to have any significant or lasting effect on blood lead levels of children or adults.

The health risk assessment evaluated lead risks for long-term exposure to a child walking along the haul road and exposed to street dust via ingestion and inhalation of particulates. The study covered current street dust conditions as well as those on August 29, 2001, prior to the haul road remediation program begun by Doe Run.

"Our objective was to relate the levels of lead concentrates along the roads in Herculaneum to the level of risk to human health," said Dr. Bowers. "The results of this study will also have an impact on determining the acceptable lead concentrate levels on roads used by haul trucks outside the Herculaneum area. While each section of road used by the haul trucks has its own specific set of conditions, the model established for this study will provide a method to assess the risks to human health posed by the presence of lead concentrate along these other roads."

"This new scientific information should be encouraging news to everyone in Herculaneum," said Barbara Shepard, vice president of human resources and community relations for Doe Run. "We're pleased to know that the measures we are taking in the Herculaneum community, including our accelerated cleanup program, the voluntary home purchase plan, the daily cleaning of streets and the development and implementation of a comprehensive Transportation Plan, are all working to address the concerns of residents."

Dr. Bowers received her Ph.D. in Geochemistry from the University of California - Berkeley, and has lectured at Massachusetts Institute of Technology and Harvard University. Gradient Corporation is a leading consultant to business, industry and the media regarding soil contaminant cleanups, human health risk assessments and related matters. The full content of the Herculaneum haul road study can be accessed at www.doerun.com.

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Haul Road Risk Assessment
The Doe Run Company
Herculaneum, Missouri

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May 8, 2002

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List of Acronyms

DRC	Doe Run Company
EPC	exposure point concentration
IEUBK	Integrated Exposure Uptake Biokinetic Model
ISCST3	Industrial Source Complex, Short Term
MDNR	Missouri Department of Natural Resources
mg/kg	milligrams per kilogram
NJDEP	New Jersey Department of Environmental Protection
PbB	blood lead level
ppm	parts per million
USEPA	U.S. Environmental Protection Agency
XRF	x-ray fluorescence

Executive Summary

The Doe Run Company operates a primary lead smelter on Main Street in Herculaneum, Missouri. As part of its operations, Doe Run receives truck shipments of lead ore concentrate as a raw material. Elevated levels of lead have been found in street dust samples collected along the haul roads, which have been attributed to lead ore concentrate from the trucks on their way to and from the facility. This report presents the results of a risk assessment that was performed to evaluate human health risks from exposure to lead in street dust, along the haul roads that are used by the trucks hauling concentrated lead ore to the Doe Run facility in Herculaneum, Missouri. The results of this evaluation were used to develop objective criteria for lead levels in street dust to protect human health and support removal of signs prohibiting pedestrian use of streets and sidewalks along haul roads.

Risks were evaluated for an adult and child who walk along the haul road. These receptors are assumed to be exposed to lead in street dust through incidental ingestion, which may occur through hand-to-mouth contact, and inhalation of particulates. Blood lead models developed and recommended by the USEPA were used to predict the incremental increase in blood lead level for individuals exposed to street dust *via* these pathways.

The results of the blood lead modeling indicate that exposure to lead ore concentrate in street dust is not expected to have any lasting or significant effect on blood lead levels for either children or adults. For a child with long-term exposure, the predicted average incremental increase in blood lead level ranged from 0.12 to 0.4 µg/dL for the post-remediation data (current conditions), and 0.03 to 3.5 µg/dL for the pre-remediation data (collected in August, 2001). For short-term exposure to a hot-spot along the haul road, the predicted incremental blood lead increase for a child is 0.3 µg/dL, and the child's blood lead level recovers to its previous baseline within approximately 4 days. For long-term exposures in adults, the predicted incremental increase in blood lead level due to exposure to street dust ranged from 0.03 to 0.09 µg/dL for the post-remediation data, and from 0.009 to 0.8 µg/dL for the pre-remediation data.

The predicted incremental increases in blood lead levels are quite small for a number of reasons, including the low bioavailability of lead in the lead ore concentrate, the low street dust loadings due to the implementation of daily street cleanings, and the fact that a child is expected to obtain only a small fraction of his total soil/dust intake from street dust. Gradient therefore concludes that current street dust lead concentrations do not pose a significant health risk for adult or child pedestrians along the haul roads in Herculaneum.

1 Introduction

1.1 Objective

The objective of this risk assessment was to evaluate human health risks from exposure to lead in street dust, along the haul roads that are used by the trucks hauling concentrated lead ore to the Doe Run facility in Herculaneum, Missouri. The results of this evaluation were used to develop objective criteria for lead levels in street dust to support removal of signs prohibiting pedestrian use of streets and sidewalks along haul roads.

1.2 Site Background

The Doe Run Company operates a primary lead smelter on Main Street in Herculaneum, Missouri. As part of its operations, Doe Run receives lead ore concentrate from mining and milling operations located in Missouri. Lead ore concentrate has been brought to the facility on trucks for approximately the past three years. The trucks drive on public streets on their way to and from the facility.

On August 21, 2001, the Missouri Department of Natural Resources (MDNR) responded to citizens' complaints related to dust on the streets of Herculaneum. MDNR collected and analyzed a sample of road dust, which was found to contain 300,000 mg/kg lead. The U.S. Environmental Protection Agency (USEPA) collected additional street dust samples on August 30, 2001, and screened the samples for lead using x-ray fluorescence (XRF). Lead concentrations in these dust samples ranged from 30,000 to 300,000 mg/kg, located primarily along hauling routes and approximately 50 yards down intersecting side streets. MDNR and USEPA concluded that the high lead levels in the street dust were attributable to lead ore concentrate from trucks hauling lead ore concentrate to and from the Doe Run smelter, along primary and secondary hauling routes, including Station Street, Brown Street, Joachim Avenue, and Main Street (MDNR, 2001).

In response to a request from USEPA, Doe Run conducted certain activities, including street cleaning of haul routes and removal of a small accumulation of ore in a road depression at the intersection of Station and Main, around September 1, 2001. For the purpose of this report, these cleaning activities are referred to as the "remediation".

In the first week of September 2001, due to elevated levels of lead in street dust, MDNR erected signs along the haul route that prohibited pedestrian use of streets and sidewalks along the haul roads.

1.3 Risk Assessment Process

Lead health effects that have been studied and reported in the literature are associated with long-term, or chronic, exposure. Young children are most at risk for the health effects associated with lead because of their developing neurosystems. Adult women of child-bearing age are also considered to be a population at risk due to the potential effects of lead exposure on the developing fetus.

The general process of risk assessment involves several steps which are common to all risk assessments. The National Academy of Sciences defines risk assessment as the evaluation of the toxic properties of a chemical combined with the conditions under which an individual may be exposed to that chemical (NRC, 1994). USEPA (1989) lays out the four parts to every risk assessment:

- Hazard identification: Chemicals for which there are potential toxic effects are identified, and environmental information about those chemicals is collected.
- Exposure evaluation: The categories of individuals who may be exposed are considered, and the routes of possible exposure, *e.g.,* inhalation or ingestion, are identified.
- Dose-response evaluation: The relationship between amount of exposure to the chemical and the extent of toxic effect is quantified.
- Risk characterization: The results of the three steps above are combined to determine the likelihood that individuals will experience toxic effects as a result of their particular, site-specific exposures.

USEPA varies somewhat from these standard risk assessment steps in assessing the health effects of lead in that it recommends use of a blood lead model, which predicts the amount of lead in blood as a result of exposure to levels of lead in the environment (USEPA, 1994). The blood lead level is compared to a target level of concern, currently set by the Centers of Disease Control as 10 μg/dL (CDC, 1991). EPA recommends that lead exposures be minimized such that a child has no more than a 5% probability of exceeding a blood lead level of 10 μg/dL.

In this report we follow the basic steps required by U.S. EPA to perform a lead risk assessment. First, we evaluate the available environmental data for lead to determine whether it is useable and sufficient to characterize risks. Then, we evaluate the type of individuals (*e.g.*, adults and children) (the receptors) who might be exposed to lead. We then determine how often and for how long these individuals might be exposed (the exposure frequency and duration). We then evaluate the different ways that lead might get into an individual's body (the exposure pathways). Next, we calculate the average lead concentration that people might be exposed to, for each medium in each exposure area (the exposure point concentrations, or EPCs). In the risk characterization step, we use the information gathered in the previous steps to perform blood lead modeling. In this risk assessment, we are considering only the effects of exposure to lead ore concentrate present on the haul roads rather than the broader spectrum of lead exposures, which includes exposures to lead in soil, residential dust, water, diet, and air. Therefore, we use the blood lead model to predict the increment to an individual's baseline blood lead level that he might experience as a result of exposure to the lead source of interest, in this case, lead ore concentrate on the haul roads. Predicted blood lead levels are compared to regulatory levels to determine if the individual may experience an undue risk due to his exposure to the lead source of interest.

Section 2 of this report summarizes all of the street dust data available for Herculaneum. Section 3 presents the exposure assessment, including the receptors, exposure frequencies, and exposure pathways; and the exposure point concentrations. Section 4 discusses the bioavailability of lead in the lead ore concentrate that is hauled by truck to the Doe Run facility. Section 5 presents the risk characterization, which includes the results of the blood lead modeling for long-term exposures by children and adults, and short term exposures for children. Section 6 presents the results of an analysis to determine acceptable levels of lead in street dust. Section 7 presents the analysis of uncertainties associated with the risk assessment. Section 8 presents the summary and conclusions.

2 Data Summary

2.1 Street Dust Data

USEPA collected a total of 16 street dust samples on August 29, 2001. These are considered pre-remediation samples for the purpose of this risk assessment. The samples were analyzed by XRF. The USEPA pre-remediation data are presented in Table A-1 in Appendix A. Sampling locations are shown on Figure 1. Street dust lead concentrations ranged from 4260 to 294,000 mg/kg (ppm) from sample locations along the haul route, and from 1030 to 8300 mg/kg from areas away from the haul route and not close to the Doe Run smelter.

USEPA performed several rounds of street dust sampling between November, 2001 and February, 2002. The samples were analyzed in a laboratory, presumably using an acid digestion method. The data are presented in Table A-2 in Appendix A. Sampling locations are shown on Figure 1. Street dust lead concentrations in this data set range from 120 to 190,000 mg/kg.

The Doe Run Company (DRC) performed several rounds of street dust sampling between November, 2001 and February 2002. The samples were analyzed by XRF. The data are presented in Table A-3 in Appendix A. Sampling locations are shown on Figure 1. Street dust lead concentrations in this data set range from 258 to 255,000 mg/kg.

2.2 Street Dust Loadings

Street dust loadings were calculated for the Doe Run data, using the sample weights divided by the sample area of six square feet. Street dust loadings averaged about 0.2 mg/cm^2 on the haul roads, and about 0.6 mg/cm^2 at the truck dump and the intersection of Station and Main Streets (Table A-4, Appendix A). Dust loadings could not be calculated from the USEPA data because the sample weights were not included with the data.

3 Exposure Assessment

3.1 Receptors and Exposure Frequency

The receptors evaluated for exposure to street dust along the haul roads included a young child (1 to 6 years old) and an adult (17 to 45 years old). The adult receptor in lead evaluations is considered by USEPA to be a woman of child-bearing age (USEPA 1996). Both adult and young child receptors were conservatively assumed to walk along the haul road one hour per day, seven days per week, 52 weeks per year.

3.2 Exposure Pathways

The child and adult are assumed to be exposed to street dust *via* incidental ingestion and inhalation of particulates. Humans have incidental soil ingestion while performing typical daily activities, such as eating or touching their mouths. This exposure assessment assumes that resident children and adults are exposed to dust by walking along the edge of the street, or that they walk on the sidewalk and dust lead levels on the sidewalk are the same as those on street.

3.2.1 Incidental Ingestion

We assumed that the child initially picks up street dust on their hands by placing the palm side of both hands onto the street, and that the child would ingest some portion of the dust on his hands through hand-to-mouth activity. Alternatively, a child may drop a toy into the street dust, and in picking up the toy, contact dust either on the street or on the toy. The exact proportion of street dust that the child might ingest from his hands is difficult to estimate, however. Instead, we assumed the child is exposed to street dust for approximately one hour per day as he walks down the street. For both the child and the adult, we assumed that the daily ingestion of soil and dust is spread evenly throughout the day. We thus assumed that during the one hour per day that they walk along the haul road, they obtain approximately 10% of their total daily soil ingestion. Therefore, the street dust ingestion rate was assumed to be 10% of the total daily soil ingestion rate. For example, for a child with a total daily soil/dust ingestion rate of 100 mg/day, we assume that they ingest approximately 10 mg/day of street dust.

The assumption of 10% ingestion of street dust was further assessed by comparing street dust loadings to typical hand loadings to determine how much contact with the street would be required to yield the expected ingestion value. The average street dust loading from the Doe Run sampling was 0.2 mg/cm^2 on the haul roads (Table A-4, Appendix A). USEPA has assumed (for PCBs) that approximately 50% of material on a surface will be transferred to the skin as a result of direct contact, based on an Office of Toxic Substances assessment (Hubbard, 1995). USEPA has also assumed that approximately 10% of the material on the hand surface area will be transferred to the mouth. The mean surface area of two palms for a 2-6 year old child is 130 cm^2 (USEPA, 1997). With a street dust loading of 0.2 mg/cm^2, a child would get 26 mg on his palms. If he ingests 10% of this amount, he would ingest 2.6 mg of street dust. This value is about one-fourth of the 10 mg/day assumed above, therefore, the assumption that a child obtains 10% of his total soil/dust ingestion from street dust is considered to be a conservative assumption.

3.2.2 Inhalation Exposure to Street Dust Particulates in Air

The adult and child were assumed to inhale particulates from street dust as they walk down the street. An air model was used to predict the incremental annual average air lead concentration that would result from particulate re-entrainment due to vehicular traffic on haul roads. The air modeling is described in Section 3.3.2. The adult was assumed to be exposed to this incremental air lead concentration for one hour per day. The child was assumed to be exposed to this incremental air lead concentration 24 hours per day, because the USEPA blood lead model for children assumes that the air exposure concentration is constant. This is a conservative assumption, since the exposure scenario assumes the child walks along the haul road for only one hour per day.

3.2.3 Secondary Ingestion of Dust Tracked on Shoes Back to Primary Residence

A certain amount of street dust may be tracked on shoes into the primary residence. The street dust will mix with other dust inside the home, thus the interior dust lead concentration will be less than the average street dust concentration. We assume that the child obtains 10% of his total daily soil/dust ingestion from street dust, whether he is exposed directly on the street, or to street dust tracked inside the home. Thus, we did not evaluate exposure to interior dust tracked from the street as a separate pathway.

3.2.4 Dermal Contact with Street Dust

Dermal contact with street dust was not evaluated as lead uptake from dermal contact is very low. The USEPA Dermal Risk Assessment Guidance (USEPA, 1999) does not list a dermal absorption value for lead, and states that there are "no default dermal absorption values for ... inorganic classes of compounds" (USEPA, 1999; p. 3-24). Blood lead models used by USEPA for lead risk assessment do not include a component for dermal contact.

3.3 Exposure Point Concentrations (EPCs)

3.3.1 Street Dust EPCs

For the evaluation of long-term exposure to street dust, the adult and child receptors are assumed to be exposed to the average street dust concentration within an exposure area encompassing several blocks.

We also evaluated exposure for a child who has a short-term exposure to a hot-spot, represented by the maximum street dust lead concentration detected in any of the three data sets (294,000 mg/kg). We used a one-day exposure for the short-term exposure, because the child is assumed not to go back to the same hot spot on subsequent days.

To derive the average concentration for the long-term exposures, the pre- and post-remediation street dust data were aggregated into exposure zones, with each zone encompassing several blocks. The zones were drawn based on the locations where samples were collected. Pre- and post-remediation sample data were each segregated into five exposure zones (Post-remediation Zones A to E, and Pre-remediation Zones F to J). The sample locations and exposure zones are shown on Figure 1. The pre- and post-remediation exposure zones are different because the samples were collected in different areas.

The pre-remediation data consists of USEPA samples collected on August 29, 2001 (Table A-1). Only one sample was collected at each location, therefore, the data were used without aggregation. We derived the average street dust concentration in each exposure zone by averaging the results for samples within that zone.

The post-remediation data consist of two data sets: USEPA data and DRC data collected between November, 2001 and February, 2002 (Tables A-2 and A-3). The USEPA samples were analyzed by a laboratory wet chemistry method, while the DRC samples were analyzed by XRF. Technically, data generated from two different analysis methods should not be combined. However, the two data sets were combined in calculating EPCs, because lead was detected at substantial concentrations in all samples. The different method detection limits should therefore not affect the calculation of the average.

Each post-remediation data set has multiple samples per location, collected on different dates. First, we derived an average concentration for each location by averaging the samples collected on multiple dates at each location (Table A-5). Second, we derived the EPC (average street dust concentration) for each exposure zone by averaging the average for each sample location within that zone. Street dust EPCs for each exposure zone are presented in Table 3-1.

Table 3-1
Street Dust EPCs

Remediation	Exposure Zone	Description	Number of Sample Locations in Exposure Zone	Street Dust Lead EPC (mg/kg)	Incremental Air Lead EPC (μg/m³)
Post	A	Approaching Plant *via* Main St.	4	11,397	0.043
Post	B	Adjacent to Plant	8	21,033	0.079
Post	C	Residential Area not on Haul Route	6	14,357	0.054
Post	D	Haul Route Area	2	14,232	0.021
Post	E	Remote Area	6	5,730	0.036
Pre	F	Pre-Remediation Zone Approaching Plant *via* Broadway	1	2,860	0.011
Pre	G	Pre-Remediation Zone Adjacent to Plant	3	177,100	0.664
Pre	H	Pre-Remediation Zone Residential Area not on Haul Route	2	1,985	0.007
Pre	I	Pre-Remediation Haul Route Area	5	70,512	0.264
Pre	J	Pre-Remediation Zone Remote Area	3	14,200	0.053

3.3.2 Air EPCs

An EPA-recommended air model was used to predict the annual average air lead concentration along the street that would result solely from particulate re-entrainment due to vehicular traffic on the haul roads. Particulate emissions from the street are transported and dispersed by winds over the surrounding area. The predicted air concentrations were estimated using the current version of the

Industrial Source Complex, Short Term (ISCST3) air model, Version 02035, which is recommended as a preferred model by EPA for regulatory purposes (USEPA, 1995a).

Particle re-entrainment was calculated based on expected traffic patterns, using the average street dust lead concentration within each exposure zone. The AP-42 emission factor for paved roads was used (USEPA, 1995b). Expected traffic patterns were based on a traffic study conducted for Doe Run in 1992 (Crawford, Bunte, Brammeier, 1992). This report indicated that Station Street, between Main and Church Streets, has an average traffic volume of 1050 vehicles per day. Doe Run estimated that they receive 50 truckloads of lead ore per day. We assumed an average daily traffic volume of 1100 vehicles per day. The calculation of the particulate emissions factor is presented in Appendix B.

The meteorological data used in the air modeling consisted of one year of hourly surface wind data taken at Lambert Field in St. Louis, which is the closest National Weather Service meteorological station to Herculaneum. The meteorological data, for the calendar year 1990, were obtained from the EPA air modeling web site (*www.epa.gov/ttn/scram*). The upper air (temperature inversion) data were obtained from the closest upper air measurement site in Peoria, IL.

In the ISCST3 air modeling, the road was assumed to be 45 feet (13.7 m) wide, and to run east-west. The highest predicted annual average air concentration was at the north edge of the road, and decreased with distance away from the road. The highest predicted air concentration at the north edge of the road was used as the air EPC.

The incremental air lead EPCs due to particle re-entrainment calculated for each exposure zone are presented in Table 3-1.

4 Bioavailability of Lead in Lead Ore Concentrate

Bioavailability, the factor representing the amount of biologically-available lead in street dust or soil, varies depending on food intake, lead intake, and the chemical properties of the lead itself (USEPA 1996). An *in vitro* bioavailability test was conducted on two composite samples (one original sample and one duplicate sample) of lead ore concentrate from Doe Run in November, 2001. The composite lead ore samples were weighted to contain the proportions of lead ore from the four mills that supply Doe Run with lead ore concentrate. These samples were collected by Doe Run and shipped to the laboratory. The analysis was conducted by Dr. John W. Drexler at the Laboratory for Environmental and Geological Studies at the University of Colorado in Boulder, CO (Drexler, 2001). The bioavailability report is provided as Appendix C.

The *in vitro* test method was developed at the University of Colorado (Boulder), and calibrated to EPA's Region 8 Swine Model. The test method is reported to have a high correlation to the Swine Model for Lead (r=0.96). In the two ore samples, the lead concentration was 790,000 mg/kg, and the relative bioavailability for lead was determined to be 0.9% and 1.0%. The Drexler report indicated that these low relative bioavailabilities were consistent with lead sulfide, based on previous speciation studies.

The Drexler report indicates that the relative bioavailability of lead in the lead ore concentrate is on the order of 1%. USEPA believes that the high lead levels detected in street dust are due to lead ore concentrate that has fallen off the delivery trucks. Therefore, we have assumed a relative lead bioavailability of 1% for the lead in street dust.

5 Risk Characterization

Risks from exposure to lead in street dust were evaluated for an adult and child who walk along the haul road for one hour each day. Blood lead models were used to calculate the increment to an individual's blood lead level that might arise from exposure to street dust, over and above the blood lead level that would exist in the absence of this exposure. We took this approach of calculating an incremental blood lead level because of the difficulty associated with estimating lead levels due to other sources of lead exposure in Herculaneum and the wide range of blood lead levels that have been observed in the community. By assessing only the increment in blood lead levels associated with the haul roads alone, we are best able to determine whether the signs prohibiting pedestrian use are necessary.

5.1 Child – Long Term Exposure

USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model (USEPA, 1994) was used to evaluate the increment to a child's blood lead level resulting from long-term exposure to the street dust.

The child is assumed to walk along the haul road for one hour per day, 365 days/year. We assume that he obtains 10% of his total daily soil/dust ingestion from street dust. Thus, we used 10% of the model's default soil/dust ingestion rates (8.5 to 13.5 mg/day, depending on the age of the child).

The soil/dust EPCs were the average street dust concentrations in each exposure zone. The air EPCs were the predicted increase in the annual average air concentration due to particle re-entrainment (Section 3.3.2). Lead intakes from both water and diet were set to zero, in order to calculate only the incremental blood lead level due to exposure to street dust. The percent of soil/dust absorption was set to 0.5%, based on 1% relative bioavailability from the Drexler study, and 50% absorption of soluble lead.

A total of four IEUBK model runs were conducted. The modeling was conducted for the exposure zones with the highest and lowest street dust EPCs, for both pre- and post-remediation street dust data (Zones B, E, G and H). The results of the IEUBK modeling are presented in Table 5-1. Incremental blood lead levels range from 0.1 to 0.4 µg/dL for post-remediation data, and from 0.03 to 3.5 µg/dL for pre-remediation data. The incremental blood lead levels for the post-remediation data are small and indicate that, under current conditions, exposure to street dust is not expected to have a significant impact on child blood lead levels. The results for pre-remediation data in Zone G (adjacent to the plant) indicate that a child could have had a blood lead increment as high as 3.5 µg/dL, due to long term daily exposure to street dust at an average concentration of 177,100 mg/kg. This result indicates the importance of the street cleaning that is currently conducted. Since the streets are now cleaned on a daily basis, the average dust concentrations are significantly lower than pre-remediation levels.

Table 5-1
IEUBK Model Results
Blood Lead Increment from Street Dust Ingestion and Inhalation

	Post-Remediation		Pre-Remediation	
	Zone B	Zone E	Zone G	Zone H
Age (yr)	Adjacent to Plant	Remote Area	Adjacent to Plant	Remote Residential
1-2:	0.6	0.2	4.7	0.1
2-3:	0.5	0.1	4.2	0.1
3-4:	0.5	0.1	3.9	0.0
4-5:	0.4	0.1	3.2	0.0
5-6:	0.3	0.0	2.7	0.0
6-7:	0.3	0.0	2.2	0.0
Average Blood Lead Increment (1-7yr old) (µg/dL)	**0.4**	**0.12**	**3.5**	**0.03**
Street Dust Lead EPC (mg/kg)	21,033	5,730	177,100	1985
Air Lead EPC ($\mu g/m^3$)	0.079	0.021	0.664	0.007

5.2 Child – Short Term Exposure to Hot-Spot

As noted above, long-term exposure was evaluated for a child using the average street dust concentration within an exposure zone. In addition, we evaluated the effect on blood lead levels for a short-term (one-day) exposure to a hot-spot street dust lead concentration for a 2½ year old child. We assumed that the ingestion of lead from the hot-spot would occur as a one-time event on one day, because we assumed that the child would not go back to the same hot-spot each day.

This evaluation was performed using the O'Flaherty model, a predictive physiologically-based pharmacokinetic blood lead model developed by Dr. Ellen O'Flaherty at the University of Cincinnati (O'Flaherty, 1993 and 1995). Like the IEUBK Model, the O'Flaherty Model simulates the intake, distribution, and excretion of lead in the human body. However, the O'Flaherty Model is based on a more complete characterization of the human body that allows the model to predict the influence of lead exposure over time in both children and adults, thereby enabling the characterization of blood lead level changes in response to short-term changes in exposure.

The hot spot concentration was represented by the maximum detected street dust lead concentration (294,000 mg/kg) detected in USEPA's pre-remediation sample from the intersection of Station and Broad Streets on 8/29/01. This represents a worst-case concentration, because the streets are currently cleaned on a daily basis, and post-remediation dust lead concentrations are much lower than this.

Exposure was modeled from age 2 to 3, and the one-day exposure to the hot-spot concentration was assumed to occur when the child was 2½ years old. For the other 364 days of the year, the child was assumed to be exposed to 400 mg/kg lead in soil. The child was assumed to have a total soil/dust ingestion of 100 mg/day (USEPA, 1997). Following the methodology presented above for the IEUBK model, he was assumed to ingest 10% (10 mg/day) of dust from the street, and the street dust lead was assumed to have a relative bioavailability of 1%. The exposure frequency was one day. These inputs yield an intake of 29.4 µg of bioavailable lead from street dust.

Model results indicate that the maximum blood lead increase due to the ingestion of lead from the hot spot is 0.3 µg/dL, and the child's blood lead level recovers within approximately 4 days. The modeling results indicate that a one-time exposure to a hot-spot lead concentration of 294,000 mg/kg is not expected to have any lasting or significant effect on blood lead levels.

5.3 Adult – Long Term Exposure

USEPA's Adult Lead Model was used to evaluate adult exposure to street dust (USEPA, 1996). The model estimates the incremental increase in blood lead level due to exposure to the lead source of interest, in this case street dust. Adults will have incremental lead exposure to street dust *via* both incidental ingestion and inhalation of particulates.

Lead uptake from dust is calculated by multiplying the concentration of lead in dust by the soil/dust ingestion rate and the absorption fraction for lead in soil/dust. The incremental increase in blood lead levels due to exposure to street dust (ΔPbB) is given by:

$$\Delta PbB_{dust} = \frac{EF}{AT} \times PbD \times IR \times AF_d \times BKSF$$

where:

EF	=	Exposure Frequency – number of days during which an individual is exposed to the lead source being evaluated (days)
AT	=	Averaging Time (days)
PbD	=	Incremental street dust lead concentration (µg/g)
IR	=	Soil/dust ingestion rate (g/day)
AF_d	=	Fraction of ingested lead absorbed into the blood stream (dimensionless)
BKSF	=	Biokinetic Slope Factor (change in blood lead per µg change in daily lead uptake) (µg/dL per µg/day)

The incremental increase in blood lead levels reflecting exposure to atmospheric lead generated from particle re-entrainment of street dust is given by:

$$\Delta PbB_{air} = \frac{EF}{AT} \times \frac{ET}{24} PbA \times InhR \times AF_a \times BKSF$$

where:

PbA	=	Incremental air lead concentration (µg/m^3)
InhR	=	Inhalation rate (m^3/day)
AF_a	=	Fraction of inhaled lead absorbed into the blood stream
ET	=	Exposure Time (hr/day)

A biokinetic slope factor is used to relate increased lead uptake into the body to an incremental increase in blood lead levels for adults. The incremental increases from dust and air are summed to yield the total incremental increase in blood lead level due to street dust exposure.

The adult lead model was run for the exposure zones with the highest and lowest street dust EPCs, for both pre- and post-remediation street dust data (Zones B, E, G and H). The model input values and results are presented in Table 5-2. Incremental increases in adult blood lead levels range from 0.03 to 0.09 µg/dL for post-remediation data, and 0.01 to 0.8 µg/dL for pre-remediation data. The incremental increases in blood lead levels are quite low for both sets of data, and indicate that exposure to street dust under current conditions is not expected to have a significant impact on adult blood lead levels.

Table 5-2
Adult Lead Model Results

Ingestion Pathway		Units	Zone B	Zone E	Zone G	Zone H
Average Street Dust Lead Conc.	PbD	mg/kg	**21,033**	**5,730**	**177,100**	**1,985**
Absorption of soluble lead			0.20	0.20	0.20	0.20
Relative Bioavailability[1]	RBA		0.01	0.01	0.01	0.01
Absorption from dust	AFd		0.002	0.002	0.002	0.002
Biokinetic Slope Factor	BKSF		0.4	0.4	0.4	0.4
Exposure Frequency	EF	d/yr	365	365	365	365
Averaging time	AT	days	365	365	365	365
Ingestion Rate[2]	IR	g/day	0.005	0.005	0.005	0.005
Blood Lead Increment - Ingestion		µg/dL	**0.08**	**0.02**	**0.7**	**0.01**

Inhalation Pathway			Zone B	Zone E	Zone G	Zone H
Air Lead EPC	PbAir	µg/m^3	**0.079**	**0.021**	**0.664**	**0.007**
Inhalation rate (m^3/day)	InhR	m3/day	20	20	20	20
Fraction of inhaled lead absorbed[3]	AFa		0.32	0.32	0.32	0.32
Biokinetic Slope Factor	BKSF		0.4	0.4	0.4	0.4
Exposure Time	ET	hr/day	1	1	1	1
Exposure Frequency	EF	d/yr	365	365	365	365
Averaging time	AT	days	365	365	365	365
Blood Lead Increment - Inhalation		µg/dL	**0.008**	**0.002**	**0.07**	**0.0007**

Blood Lead Increment - Ingestion + Inhalation	**0.09**	**0.03**	**0.8**	**0.009**

Notes

1. *Relative bioavailability of lead ore from Drexler study (Drexler, 2001)*
2. *Ingestion rate of street dust is 10% of total soil/dust ingestion: 0.05 g/day x 0.1 = 0.005 g/day*
3. *USEPA Air Quality Criteria for Lead, June, 1986.*

All other input values are USEPA defaults.
PbB = Blood lead level (µg/dL)

6 Acceptable Street Dust Lead Levels

We used the IEUBK model to derive acceptable average street dust concentrations for children that would be protective of human health for both children and adults. Acceptable street dust lead levels are best evaluated as average long-term concentrations because sustained elevations in blood lead levels result from chronic exposures.

6.1 IEUBK Model Results

Acceptable average street dust concentrations were derived using the IEUBK model. The child receptor was used because the blood lead modeling results (Section 5) indicate that he is a more sensitive receptor than the adult (*i.e.*, the child has a higher blood lead increment resulting from exposure to a specified concentration). We used the criterion that the acceptable average street dust concentration should yield an incremental increase of no more than 2 µg/dL to a child's blood lead level, considering intake through both the ingestion and inhalation pathways.

The criterion of 2 µg/dL is based on a paper by Alan Stern of the New Jersey Department of Environmental Protection (NJDEP) (Stern, 1994). In determining a risk-based target lead concentration in residential soil, Stern selected a 2 µg/dL increase in blood lead level as an increment that represented a toxicologically *de minimis* contribution to blood lead concentration (Stern, 1994). This increment was selected by Stern for two reasons: 1) it represents a suitably small fraction of the CDC maximum target level of 10 µg/dL, and 2) it is less than the practical detection limit used to define the target blood lead level of 10 µg/dL.

The IEUBK model was run with the same input values as described in Section 5. We assume the child obtains 10% of his daily soil/dust ingestion from street dust. Including both the ingestion and inhalation pathway, the model results indicate that an average street dust concentration of 95,000 mg/kg would yield an average incremental increase in blood lead level of 2 µg/dL for a 1-7 year old child (Table 6-1). Thus, a dust lead concentration of 95,000 mg/kg is considered an acceptable street dust lead level, on an average basis, and would be health protective on an individual sample basis as well. Street dust concentrations below this level do not pose a significant health risk for area residents.

In the Doe Run samples collected between 11/01 and 2/02 (Table A-3), none of the individual samples exceeded a street dust lead concentration of 95,000 mg/kg, with the exception of two samples collected from Station Street on 11/16/01 (221,000 and 255,000 mg/kg). However, even for these two samples, the results of the O'Flaherty modeling for short-term exposure to a hot-spot (294,000 mg/kg) suggest that these concentrations would not present a significant risk (see Section 5.2). The dust sampling results from that four-month period, where street cleaning was conducted on a regular basis, indicate that average street dust lead levels do not currently pose a significant health risk for adult or child pedestrians walking along the haul route.

Table 6-1
IEUBK Model Results to Determine
Acceptable Street Dust Lead Concentration

Age (yr)	Blood Lead Level (µg/dL)
1-2:	2.6
2-3:	2.3
3-4:	2.2
4-5:	1.8
5-6:	1.5
6-7:	1.2
Average Blood Lead Increment for 1-7yr old (µg/dL)	1.9
Average Street Dust Lead Conc. (mg/kg)	95,000
Modeled Air Lead Conc. (µg/m^3)	0.356

6.2 Alternative Assessment of Dust Lead Loadings and Lead Concentrations

The street dust loadings and lead concentrations of the street dust can be further assessed by comparison to the dust clearance standards set in the USEPA "Lead, Identification of Dangerous Levels of Lead, Final Rule" (40 CFR Part 745, Jan. 5, 2001). The dust lead clearance standards proposed in that Rule are 40 µg/ft^2 for floors, 250 µg/ft^2 for interior window sills, and 400 µg/ft^2 for window troughs. These clearance standards are used to evaluate the effectiveness of residential cleaning following abatement for lead paint hazards. These standards, as well as others presented in the Rule, were developed following an extensive risk analysis that considered several alternative models relating environmental lead to blood lead levels, as well as the cost-effectiveness of various possible standards. Therefore, while not strictly risk-based, the standards were derived with a goal of achieving adequate public health protection.

The comparison between lead loadings on Herculaneum streets and the EPA clearance standards presented below considers the reduced bioavailability of lead ore concentrate as determined by the Drexler *in vitro* analyses (see discussion in Section 4). The Drexler analyses indicate a relative bioavailability of lead ore concentration of 1%. EPA considers the "default" relative bioavailability of lead in soil or dust, in the absence of other information, to be 60% (USEPA, 1994, 1996). Here we assume that lead in soil or dust that originates from paint has the default bioavailability of 60%. This means that the bioavailability of lead in ore concentrate relative to lead paint in dust is 1/60. Therefore, we will take the "effective" concentration of lead in the street dust to be 1/60th of the actual concentration when comparing to the paint lead clearance standards.

The table below presents the average dust loadings and average lead loadings observed on Herculaneum streets at two locations (East Road and at the intersection of Station and Main) over about a two month time period (see Table A-4, Appendix A). Dust lead concentrations during this time at these locations varied from approximately 2000 to 16,000 mg/kg. When the effective concentration, assuming a lead bioavailability of 1%, is considered, the lead loadings of 24 and 64 µg/ft^2 are similar to the floor clearance standard (40 µg/ft^2), and lower than the window sill clearance standard (250 µg/ft^2). Considering that young children are much more likely to contact and become exposed to floors and window sills in their own homes than to street pavement, these calculations demonstrate that the observed dust lead loading on Herculaneum streets does not pose a significant health threat.

Table 6-2
Street Dust and Lead Loading Levels

Location (Dates)	Average Dust Loading (mg/cm^2)	Average Lead Loading (µg/ft^2)	Average Lead Loading After Adjustment for Bioavailability (µg/ft^2)
East Road (11/01-1/02)	0.19	1410	24
Station & Main (12/01-2/02)	0.60	3860	64
All locations	0.21	19,950	330

* *Calculated using acceptable dust lead level of 95,000 mg/kg, derived in Section 6.1.*

The last row in the table above shows that the average dust loading level over all street locations and dates for which samples were taken (except for the truck dump) is 0.21 mg/cm^2. This value can be taken as most representative of a long-term haul road-wide average dust loading level given the current street sweeping and cleaning schedule in Herculaneum. Using this value, we estimate, at the proposed cleanup level for street dust of 95,000 mg/kg, that this is the equivalent of a bioavailability-adjusted dust lead loading of 330 $\mu g/ft^2$, which is less than the window trough lead paint clearance standard (400 $\mu g/ft^2$). Again, young children are more likely to contact and be exposed to a window trough in their own home than to dust on the Herculaneum streets. This further confirms that, for the current total dust loadings on the streets, the proposed cleanup level of 95,000 mg/kg should be adequately health protective for the Herculaneum community.

7 Uncertainty in Lead Risks

This section discusses uncertainties in predicted blood lead levels and associated lead risk. This discussion focuses on the IEUBK modeling results, because the results indicate that the child is the most sensitive receptor for exposure to lead.

One source of uncertainty in the blood lead modeling is due to uncertainty in the true level of lead exposure that humans receive from street dust and particulate air lead. This in turn is due to uncertainty in environmental concentrations and human intake parameters. Another uncertainty is the blood lead level which results from any specified level of lead exposure ("model uncertainty"). Model uncertainty arises from uncertainty in pharmacokinetic parameters, and also from the fact that the biological processes being modeled (absorption, distribution, clearance from all of the different body compartments) are very complex, thus the mathematical representation of these processes is likely to be an oversimplification. Sections 7.1 to 7.3 discuss uncertainties associated with lead bioavailability, soil ingestion rate, and street dust lead loadings.

7.1 Bioavailability

The lead modeling results indicate that the incremental increase to blood lead levels for a child exposed to street dust are relatively small, even though street dust lead levels are high. This finding is due in large part to the fact that the lead relative bioavailability in the lead ore concentrate is only 1%, and we assumed that lead ore concentrate represents the only source of lead in street dust. However, the relative bioavailability of 1% is based on only two samples of lead ore concentrate, one of which was a duplicate sample (Drexler, 2001). Although the composite lead ore samples were weighted to contain the proportions of lead ore from the four mills that supply Doe Run with lead ore concentrate, it is likely that there would be some variability in the bioavailability if additional composite samples of lead ore concentrate were tested. However, since the lead ore concentrate transported *via* the haul route to Doe Run all comes from these same four mills, we would still expect the bioavailability to be quite low and on the order of 1%.

It is also likely that smelter emissions contribute some lead to street dust, and that lead is likely to have a higher bioavailability than the lead in lead ore concentrate. However, due to the frequent and thorough street cleaning procedures, we expect that the contribution of air emissions to street dust will be a low percentage of total observed lead on the streets at any given time. Therefore, the lead ore concentrate bioavailability is the most reasonable value to use in the assessment.

7.2 Dust Ingestion Rate

The child is estimated to obtain 10% of his total daily soil/dust ingestion from street dust. We therefore used 10% of the IEUBK model default soil/dust ingestion rates in our analysis. The estimated dust ingestion rates are based on estimates for the amount of time per day the child walks along the haul road, the amount of dust he gets on his hands, and the amount of dust from his hands that he ingests. All of these parameters are both highly variable and highly uncertain. In order to quantify some of the uncertainty associated with the dust ingestion rate, we evaluated a child who has a dust ingestion rate fives times higher than in our original analysis; *i.e.*, street dust ingestion rates range from 42.5 to 67.5 mg/day (children ages 0 to 6 years). This evaluates a child who either has a higher than average soil/dust ingestion rate, or who ingests a greater proportion of their soil/dust from the street.

For a child with this higher soil/dust ingestion rate, the results of this analysis indicate that the incremental increase in average blood lead level could be as high as 2.1 µg/dL for the post-remediation data, and 13.4 for the pre-remediation data (Table 7-1). This indicates the necessity of the street cleaning that is currently conducted, because the street cleaning keeps the street dust loading levels low and limits the amount of dust on the street that is available for ingestion.

Table 7-1
IEUBK Model Results with 5x Dust Ingestion Rate

	Post-Remediation		**Pre-Remediation**	
	Zone B	**Zone E**	**Zone G**	**Zone H**
Age (yr)	**Adjacent to Plant**	**Remote Area**	**Adjacent to Plant**	**Remote Residential**
1-2:	2.8	0.8	16.5	0.3
2-3:	2.6	0.7	15.5	0.3
3-4:	2.4	0.7	15.0	0.2
4-5:	1.9	0.5	12.6	0.2
5-6:	1.5	0.4	10.6	0.2
6-7:	1.3	0.4	9.4	0.1
Average Blood Lead Increment (µg/dL)	**2.1**	**0.6**	**13.4**	**0.2**
Street Dust Pb Conc. (mg/kg)	21,033	5,730	177,100	1985
Air Pb Conc. (µg/m^3)	0.079	0.021	0.664	0.007

7.3 Dust Lead Loading

As noted above, we estimated that the child obtains 10% of his total soil/dust ingestion from street dust. This estimate is based partly on the street dust loading data (Table A-4), which affects the amount of dust a child gets on his hands, and in turn the amount of dust from his hands that he ingests.

The street dust loadings for individual street samples collected between 11/01 and 2/02 range from 0.02 to 1.26 mg/cm² (Table A-4). The loadings vary with date and location, probably depending in part on how recently the streets were cleaned before the sample was collected.

In Section 3.2.1, we presented an analysis of hand loading that showed that an average street dust loading of 0.2 mg/cm² would yield a dust ingestion rate of about 2.6 mg/day, which is about one-fourth of the dust ingestion rates assumed in the model (8.5 to 13.5 mg/day). Using this same approach, dust loadings of 0.65 to 1.0 mg/cm² would yield dust ingestion rates of 8.5 to 13.5 mg/day, and would thus yield a similar cleanup level. The time-averaged dust loadings for the five locations in Table A-4 are all at or below 0.66 mg/cm². Therefore, the uncertainty in dust loadings should not have a significant effect on lead risks or the acceptable street dust lead concentration.

8 Summary and Conclusions

Blood lead models were used to evaluate lead risks for an adult and child who walk along the haul road. We evaluated long- and short-term exposures with three blood lead models, using conservative input values that are expected to overestimate actual exposures.

The IEUBK model was used to evaluate lead risks for long-term exposure to a child walking along the haul road. The incremental increase in blood lead level was determined for a child exposed to street dust *via* incidental ingestion and inhalation of particulates. The average incremental increase in blood lead level ranged from 0.12 to 0.4 μg/dL for the post-remediation data (current conditions), and 0.03 to 3.5 μg/dL for the pre-remediation data (8/29/01). The results indicate that exposure to lead ore concentrate in street dust is not expected to have a significant effect on blood lead levels for children.

The O'Flaherty model was used to evaluate lead risks for short-term exposure to a hot-spot along the haul road, for a 2½ year old child. The incremental blood lead increase due to one day ingestion of dust from the hot spot is 0.3 μg/dL, and the child's blood lead level recovers to its previous baseline within approximately 4 days. The modeling results indicate that a one-time exposure to a hot-spot lead concentration of 294,000 mg/kg is not expected to have any lasting or significant effect on blood lead levels.

The Adult Lead Model was used to evaluate adult exposure to street dust *via* incidental ingestion and inhalation of particulates. The incremental increase in blood lead level due to exposure to street dust ranged from 0.03 to 0.09 μg/dL for the post-remediation data, and from 0.009 to 0.8 μg/dL for the pre-remediation data. The results indicate that exposure to lead ore concentrate in street dust is not expected to have a significant effect on blood lead levels for adults.

An acceptable street dust lead concentration of 95,000 mg/kg was determined using the IEUBK model as a concentration that would be protective of human health. Comparison of lead loading on the streets at this cleanup level and current total dust loadings with USEPA's paint clearance standards further support the health protectiveness of this concentration.

In summary, due to the low bioavailability of lead in the lead ore concentrate, the low street dust loadings due to the implementation of daily street cleanings, and the fact that a child is expected to obtain only a small fraction of his total soil/dust intake from street dust, Gradient concludes that current street dust lead concentrations, which are all well below the cleanup level of 95,000 mg/kg, do not pose a significant health risk for adult or child pedestrians along the haul route in Herculaneum.

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Appendix A

Street Dust Data

Table A-1
USEPA Region 7 Pre-remediation Dust Sampling, 8/29/01

Areas along Haul Route

Sample No.	Location	XRF Pb Conc. (ppm)
1	Intersect. Station St and Broad St., small pile	294,000
2	Intersect. Station St and Broad St., 10 ft west, small pile	229,000
3	Intersect. Brown and Curved Streets, east side	175,000
4	Intersect. Brown and Curved Streets, west side	67,000
5	West of above, on Brown St, Next to Amvets Bldg	67,500
6	Across St from Amvets, City Park with boat ramp, soil in the lawn area	4,260
7	Further west, Joachim Ave., next to pay fishing lake	38,800
8	Joachim Ave and Highway 61	37,700

Areas away from Haul Route and Not Close to Smelter

Sample No.	Location	XRF Pb Conc. (ppm)
9	Intersect Scenic and Riverview	1,170
10	Intersect Scenic and Riverview	1,030
11	Intersect Lake Dr and Commercial Blvd	4,000
12	Intersect Lake Dr and Commercial Blvd	3,600
13	Crain and Joachim Ave, west side	1,910
14	Crain and Joachim Ave, east side	2,060
15	Intersect Reservoir and Broadway, on sidewalk	2,860
16	Curved St, sidewalk, 100 yds west of plant	8,300

Reference: Memo from Jim Silver to David Conrad, EPA Region 7, 8/30/01
All samples were analyzed by XRF, Instrument: 700 Series Niton XRF

Table A-2
USEPA Region 7 Post-remediation Street Dust Sampling Data

Location	Method		Area(ft²)	Units
STATION & CROSS A				
11/1/01	Laboratory	120000	9	mg/Kg
12/4/01	Laboratory	3600	9	mg/Kg
12/11/01	Laboratory	45000	9	mg/Kg
12/18/01	Laboratory	4100	9	mg/Kg
12/26/01	Laboratory	8900	9	mg/Kg
1/3/02	Laboratory	32000	9	mg/Kg
1/9/02	Laboratory	2300	9	mg/Kg
1/16/02	Laboratory	16000	9	mg/Kg
1/22/02	Laboratory	5600	9	mg/Kg
1/29/02	Laboratory	20000	9	mg/Kg
2/5/02	Laboratory	60000	9	mg/Kg
STATION & CURVED A				
11/1/01	Laboratory	29000	9	mg/Kg
12/4/01	Laboratory	8000	9	mg/Kg
12/11/01	Laboratory	9100	9	mg/Kg
12/18/01	Laboratory	5000	9	mg/Kg
1/3/02	Laboratory	11000	9	mg/Kg
1/9/02	Laboratory	4500	9	mg/Kg
1/16/02	Laboratory	29000	9	mg/Kg
1/22/02	Laboratory	3600	9	mg/Kg
1/29/02	Laboratory	13000	9	mg/Kg
2/5/02	Laboratory	10000	9	mg/Kg

Location	Method		Area(ft²)	Units
STATION & CROSS B				
11/1/01	Laboratory	94000	9	mg/Kg
12/4/01	Laboratory	14000	9	mg/Kg
12/11/01	Laboratory	1200	9	mg/Kg
12/18/01	Laboratory	470	9	mg/Kg
12/26/01	Laboratory	3100	9	mg/Kg
1/3/02	Laboratory	13000	9	mg/Kg
1/9/02	Laboratory	590	9	mg/Kg
1/16/02	Laboratory	4200	9	mg/Kg
1/22/02	Laboratory	7600	9	mg/Kg
1/29/02	Laboratory	13000	9	mg/Kg
2/5/02	Laboratory	12000	9	mg/Kg
STATION & CURVED B				
11/1/01	Laboratory	56000	9	mg/Kg
12/4/01	Laboratory	16000	9	mg/Kg
12/11/01	Laboratory	37000	9	mg/Kg
12/18/01	Laboratory	18000	9	mg/Kg
1/3/02	Laboratory	35000	9	mg/Kg
1/9/02	Laboratory	5900	9	mg/Kg
1/16/02	Laboratory	14000	9	mg/Kg
1/22/02	Laboratory	12000	9	mg/Kg
1/29/02	Laboratory	37000	9	mg/Kg
2/5/02	Laboratory	33000	9	mg/Kg

Not enough sample to submit to the lab on 12/26/2001 for both locations.

Table A-2
USEPA Region 7 Post-remediation Street Dust Sampling Data

Location	Method		Area(ft²)	Units
BROWN & JOACHIM A				
11/1/01	Laboratory	18000	9	mg/Kg
12/4/01	Laboratory	5100	9	mg/Kg
12/11/01	Laboratory	37000	9	mg/Kg
12/18/01	Laboratory	2000	9	mg/Kg
12/26/01	Laboratory	18000	9	mg/Kg
1/3/02	Laboratory	13000	9	mg/Kg
1/9/02	Laboratory	3000	9	mg/Kg
1/16/02	Laboratory	17000	9	mg/Kg
1/22/02	Laboratory	6900	9	mg/Kg
1/29/02	Laboratory	6100	9	mg/Kg
2/5/02	Laboratory	5100	9	mg/Kg
JOACHIM & BALLFIELD A				
11/1/01	Laboratory	8200	9	mg/Kg
12/4/01	Laboratory	19000	9	mg/Kg
12/11/01	Laboratory	18000	9	mg/Kg
12/18/01	Laboratory	6000	9	mg/Kg
12/26/01	Laboratory	7700	9	mg/Kg
1/3/02	Laboratory	26000	9	mg/Kg
1/9/02	Laboratory	2800	9	mg/Kg
1/16/02	Laboratory	14000	9	mg/Kg
1/22/02	Laboratory	5400	9	mg/Kg
1/29/02	Laboratory	5900	9	mg/Kg
2/5/02	Laboratory	5500	9	mg/Kg

Location	Method		Area(ft²)	Units
BROWN & JOACHIM B				
11/1/01	Laboratory	29000	9	mg/Kg
12/4/01	Laboratory	31000	9	mg/Kg
12/11/01	Laboratory	36000	9	mg/Kg
12/18/01	Laboratory	5800	9	mg/Kg
12/26/01	Laboratory	5000	9	mg/Kg
1/3/02	Laboratory	17000	9	mg/Kg
1/9/02	Laboratory	4600	9	mg/Kg
1/16/02	Laboratory	23000	9	mg/Kg
1/22/02	Laboratory	9200	9	mg/Kg
1/29/02	Laboratory	8300	9	mg/Kg
2/5/02	Laboratory	13000	9	mg/Kg
JOACHIM & BALLFIELD B				
11/1/01	Laboratory	9600	9	mg/Kg
12/4/01	Laboratory	19000	9	mg/Kg
12/11/01	Laboratory	2300	9	mg/Kg
12/18/01	Laboratory	7300	9	mg/Kg
12/26/01	Laboratory	12000	9	mg/Kg
1/3/02	Laboratory	39000	9	mg/Kg
1/9/02	Laboratory	3800	9	mg/Kg
1/16/02	Laboratory	16000	9	mg/Kg
1/22/02	Laboratory	4900	9	mg/Kg
1/29/02	Laboratory	7400	9	mg/Kg
2/5/02	Laboratory	14000	9	mg/Kg

Table A-2
USEPA Region 7 Post-remediation Street Dust Sampling Data

Location	Method		Area(ft²)	Units
JOACHIM & 61-67 A				
11/1/01	Laboratory	8900	9	mg/Kg
12/4/01	Laboratory	1500	9	mg/Kg
12/11/01	Laboratory	2700	9	mg/Kg
12/18/01	Laboratory	2800	9	mg/Kg
12/26/01	Laboratory	3100	9	mg/Kg
1/3/02	Laboratory	3400	9	mg/Kg
1/9/02	Laboratory	500	9	mg/Kg
1/16/02	Laboratory	6700	9	mg/Kg
1/22/02	Laboratory	1800	9	mg/Kg
1/29/02	Laboratory	4200	9	mg/Kg
2/5/02	Laboratory	4800	9	mg/Kg
MAIN @ MINICIPAL PARK A				
11/1/01	Laboratory	60000	9	mg/Kg
12/4/01	Laboratory	6100	9	mg/Kg
12/11/01	Laboratory	12000	9	mg/Kg
12/18/01	Laboratory	3900	9	mg/Kg
12/26/01	Laboratory	17000	9	mg/Kg
1/3/02	Laboratory	29000	9	mg/Kg
1/9/02	Laboratory	3600	9	mg/Kg
1/16/02	Laboratory	9500	9	mg/Kg
1/22/02	Laboratory	4400	9	mg/Kg
1/29/02	Laboratory	14000	9	mg/Kg
2/5/02	Laboratory	39000	9	mg/Kg

Location	Method		Area(ft²)	Units
JOACHIM & 61-67 B				
11/1/01	Laboratory	20000	9	mg/Kg
12/4/01	Laboratory	2300	9	mg/Kg
12/11/01	Laboratory	5000	9	mg/Kg
12/18/01	Laboratory	3200	9	mg/Kg
12/26/01	Laboratory	4500	9	mg/Kg
1/3/02	Laboratory	7100	9	mg/Kg
1/9/02	Laboratory	670	9	mg/Kg
1/16/02	Laboratory	7200	9	mg/Kg
1/22/02	Laboratory	4400	9	mg/Kg
1/29/02	Laboratory	6000	9	mg/Kg
2/5/02	Laboratory	6200	9	mg/Kg
MAIN @ MUNICIPAL PARK B				
11/1/01	Laboratory	43000	9	mg/Kg
12/4/01	Laboratory	18000	9	mg/Kg
12/11/01	Laboratory	75000	9	mg/Kg
12/18/01	Laboratory	9500	9	mg/Kg
12/26/01	Laboratory	190000	9	mg/Kg
1/3/02	Laboratory	47000	9	mg/Kg
1/9/02	Laboratory	11000	9	mg/Kg
1/16/02	Laboratory	20000	9	mg/Kg
1/22/02	Laboratory	16000	9	mg/Kg
1/29/02	Laboratory	28000	9	mg/Kg
2/5/02	Laboratory	27000	9	mg/Kg

Table A-2
USEPA Region 7 Post-remediation Street Dust Sampling Data

Location	Method		Area(ft²)	Units
534 MAIN A				
11/1/01	Laboratory	23000	9	mg/Kg
12/11/01	Laboratory	6000	9	mg/Kg
12/18/01	Laboratory	3000	9	mg/Kg
12/26/01	Laboratory	16000	9	mg/Kg
1/3/02	Laboratory	12000	9	mg/Kg
1/9/02	Laboratory	2300	9	mg/Kg
1/16/02	Laboratory	9900	9	mg/Kg
1/22/02	Laboratory	1200	9	mg/Kg
1/29/02	Laboratory	8900	9	mg/Kg
2/5/02	Laboratory	8000	9	mg/Kg

Location	Method		Area(ft²)	Units
543 MAIN B				
11/1/01	Laboratory	79000	9	mg/Kg
12/11/01	Laboratory	38000	9	mg/Kg
12/18/01	Laboratory	5500	9	mg/Kg
12/26/01	Laboratory	60000	9	mg/Kg
1/3/02	Laboratory	66000	9	mg/Kg
1/9/02	Laboratory	6100	9	mg/Kg
1/16/02	Laboratory	45000	9	mg/Kg
1/22/02	Laboratory	7700	9	mg/Kg
1/29/02	Laboratory	26000	9	mg/Kg
2/5/02	Laboratory	16000	9	mg/Kg

Not enough sample to submit to the lab on 12/4/2001 for both locations.

Location	Method		Area(ft²)	Units
926 DALE A				
11/1/01	Laboratory	6400	9	mg/Kg
12/4/01	Laboratory	1800	9	mg/Kg
12/11/01	Laboratory	2300	9	mg/Kg
12/18/01	Laboratory	630	9	mg/Kg
12/26/01	Laboratory	2400	9	mg/Kg
1/3/02	Laboratory	2200	9	mg/Kg
1/9/02	Laboratory	400	9	mg/Kg
1/16/02	Laboratory	420	9	mg/Kg
1/22/02	Laboratory	210	9	mg/Kg
1/29/02	Laboratory	1300	9	mg/Kg
2/5/02	Laboratory	2300	9	mg/Kg

Location	Method		Area(ft²)	Units
926 DALE B				
11/1/01	Laboratory	2200	9	mg/Kg
12/4/01	Laboratory	1100	9	mg/Kg
12/11/01	Laboratory	680	9	mg/Kg
12/18/01	Laboratory	630	9	mg/Kg
12/26/01	Laboratory	1100	9	mg/Kg
1/3/02	Laboratory	610	9	mg/Kg
1/9/02	Laboratory	6600	9	mg/Kg
1/16/02	Laboratory	1100	9	mg/Kg
1/22/02	Laboratory	1800	9	mg/Kg
1/29/02	Laboratory	3900	9	mg/Kg
2/5/02	Laboratory	2100	9	mg/Kg

Table A-2
USEPA Region 7 Post-remediation Street Dust Sampling Data

Location	Method		Area(ft²)	Units
223 BROADWAY A				
11/1/01	Laboratory	2600	9	mg/Kg
12/4/01	Laboratory	670	9	mg/Kg
12/11/01	Laboratory	420	9	mg/Kg
12/18/01	Laboratory	610	9	mg/Kg
12/26/01	Laboratory	810	9	mg/Kg
1/3/02	Laboratory	650	9	mg/Kg
1/9/02	Laboratory	380	9	mg/Kg
1/16/02	Laboratory	180	9	mg/Kg
1/22/02	Laboratory	560	9	mg/Kg
1/29/02	Laboratory	680	9	mg/Kg
2/5/02	Laboratory	1300	9	mg/Kg
SCENIC @ CEMETERY A				
11/1/01	Laboratory	1400	9	mg/Kg
12/4/01	Laboratory	640	9	mg/Kg
12/11/01	Laboratory	1100	9	mg/Kg
12/18/01	Laboratory	180	9	mg/Kg
12/26/01	Laboratory	610	9	mg/Kg
1/3/02	Laboratory	400	9	mg/Kg
1/9/02	Laboratory	430	9	mg/Kg
1/16/02	Laboratory	480	9	mg/Kg
1/22/02	Laboratory	240	9	mg/Kg
1/29/02	Laboratory	540	9	mg/Kg
2/5/02	Laboratory	500	9	mg/Kg

Location	Method		Area(ft²)	Units
223 BROADWAY B				
11/1/01	Laboratory	2700	9	mg/Kg
12/4/01	Laboratory	1400	9	mg/Kg
12/11/01	Laboratory	460	9	mg/Kg
12/18/01	Laboratory	520	9	mg/Kg
12/26/01	Laboratory	390	9	mg/Kg
1/3/02	Laboratory	120	9	mg/Kg
1/9/02	Laboratory	290	9	mg/Kg
1/16/02	Laboratory	230	9	mg/Kg
1/22/02	Laboratory	520	9	mg/Kg
1/29/02	Laboratory	600	9	mg/Kg
2/5/02	Laboratory	1800	9	mg/Kg
SCENIC @ CEMETERY B				
11/1/01	Laboratory	2800	9	mg/Kg
12/4/01	Laboratory	1700	9	mg/Kg
12/11/01	Laboratory	650	9	mg/Kg
12/18/01	Laboratory	490	9	mg/Kg
12/26/01	Laboratory	680	9	mg/Kg
1/3/02	Laboratory	1000	9	mg/Kg
1/9/02	Laboratory	320	9	mg/Kg
1/16/02	Laboratory	910	9	mg/Kg
1/22/02	Laboratory	530	9	mg/Kg
1/29/02	Laboratory	1400	9	mg/Kg
2/5/02	Laboratory	380	9	mg/Kg

A=Right side of road facing plant
B=Left side of road facing plant
Note: Samples collected on 11/9, 11/15, & 11/21 were reported in ug/Filter and will not be used in determining road lead levels.

Table A-3
Doe Run Street Sampling Data

Date	Location	Dust Lead Conc. (mg/kg)
11/5/01	East Road	2760
11/5/01	East Road	1770
11/8/01	East Road	9020
11/8/01	East Road	8030
11/9/01	East Road	7740
11/9/01	East Road	5640
11/13/01	East Road	7100
11/13/01	East Road	10300
11/13/01	East Road	10700
11/16/01	East Road	3180
11/16/01	East Road	4540
11/16/01	East Road	5730
11/27/01	East Road	6580
11/27/01	East Road	6310
11/27/01	East Road	5940
12/3/01	East Road	4650
12/3/01	East Road	4470
12/3/01	East Road	4940
12/18/01	East Road	3619
12/18/01	East Road	3958
12/18/01	East Road	4057
1/9/02	East Road	8320
1/9/02	East Road	8520
1/9/02	East Road	9500
1/21/02	East Road	8270
1/21/02	East Road	7420
1/21/02	East Road	6760
1/29/02	East Road	11700
1/29/02	East Road	11100
1/29/02	East Road	12200
10/31/01	Main & Curved	1400
11/8/01	Main & Curved	3000
11/8/01	Main & Curved	3340
12/3/01	Main & Curved	2520
12/3/01	Main & Curved	2090
12/3/01	Main & Curved	2080
12/13/01	Main & Curved	2600
12/13/01	Main & Curved	2508
12/13/01	Main & Curved	2560
1/4/02	Main & Curved	1050
1/4/02	Main & Curved	1170
1/4/02	Main & Curved	1340
1/16/02	Main & Curved	5970
1/16/02	Main & Curved	5180
1/16/02	Main & Curved	5510
1/29/02	Main & Curved	9400
1/29/02	Main & Curved	9230
1/29/02	Main & Curved	9340
1/29/02	Main & Curved	4230
1/29/02	Main & Curved	3700
1/29/02	Main & Curved	4050
2/8/02	Main & Curved	4230
2/8/02	Main & Curved	3700
2/8/02	Main & Curved	4050
2/22/02	Main & Curved	333
2/22/02	Main & Curved	298
2/22/02	Main & Curved	258
12/5/01	Station & Main	16600
12/5/01	Station & Main	16100

Table A-3
Doe Run Street Sampling Data

Date	Location	Dust Lead Conc. (mg/kg)
12/5/01	Station & Main	14400
12/13/01	Station & Main	3289
12/13/01	Station & Main	3249
12/13/01	Station & Main	3240
1/24/02	Station & Main	16900
1/24/02	Station & Main	16100
1/24/02	Station & Main	15700
2/28/02	Station & Main	16900
2/28/02	Station & Main	16100
2/28/02	Station & Main	15700
11/5/01	Station Street	8000
11/5/01	Station Street	6140
11/13/01	Station Street	1360
11/13/01	Station Street	1210
11/13/01	Station Street	1050
11/16/01	Station Street	255000
11/16/01	Station Street	221000
11/16/01	Station Street	14500
11/21/01	Station Street	588
11/21/01	Station Street	586
11/21/01	Station Street	469
11/27/01	Station Street	3450
11/27/01	Station Street	3260
11/27/01	Station Street	3220
12/21/01	Station Street	19600
12/26/01	Station Street	9700
12/26/01	Station Street	6670
12/26/01	Station Street	1260
1/4/02	Station Street	3960
1/4/02	Station Street	3590
1/4/02	Station Street	3520
1/11/02	Station Street	702
1/11/02	Station Street	510
1/11/02	Station Street	492
1/16/02	Station Street	1730
1/16/02	Station Street	1690
1/16/02	Station Street	1640
1/16/02	Station Street	1190
1/16/02	Station Street	1130
1/16/02	Station Street	1060
2/8/02	Station Street	1190
2/8/02	Station Street	1130
2/8/02	Station Street	1060
10/31/01	Truck Dump	776
11/21/01	Truck Dump	4297
11/21/01	Truck Dump	4419
11/21/01	Truck Dump	3948
12/18/01	Truck Dump	1389
12/18/01	Truck Dump	1309
12/18/01	Truck Dump	1327
1/9/02	Truck Dump	41900
1/9/02	Truck Dump	42600
1/9/02	Truck Dump	44600
1/10/02	Truck Dump	9660
1/10/02	Truck Dump	9540
1/10/02	Truck Dump	9630
1/11/02	Truck Dump	12100
1/11/02	Truck Dump	12100
1/11/02	Truck Dump	11100

Table A-3
Doe Run Street Sampling Data

Date	Location	Dust Lead Conc. (mg/kg)
1/21/02	Truck Dump	12300
1/21/02	Truck Dump	13000
1/21/02	Truck Dump	14800
1/24/02	Truck Dump	1530
1/24/02	Truck Dump	1340
1/24/02	Truck Dump	1240
2/22/02	Truck Dump	5710
2/22/02	Truck Dump	5320
2/22/02	Truck Dump	5330
2/28/02	Truck Dump	5710
2/28/02	Truck Dump	5320
2/28/02	Truck Dump	5330

Note: All samples were analyzed by XRF.

Table A-4
Doe Run Street Sampling Data
Dust and Dust Lead Loadings

Date	Location	Lead Conc (mg/kg)	Sample Weight (g)	Dust Loading (mg/cm^2)	Avg Dust Loading (mg/cm^2)	Dust Lead Loading (μg/ft^2)	Avg Dust Lead Loading (μg/ft^2)
11/5/01	East Road	2760	1.14	0.20		524	
11/8/01	East Road	9020	0.94	0.17		1413	
11/9/01	East Road	7740	1.11	0.20		1432	
11/13/01	East Road	7100	0.7	0.13		828	
11/16/01	East Road	3180	0.41	0.07		217	
11/27/01	East Road	6580	0.47	0.08		515	
12/3/01	East Road	4650	0.59	0.11		457	
12/18/01	East Road	3619	0.43	0.08		259	
1/9/02	East Road	8320	1.51	0.27		2094	
1/21/02	East Road	8270	2.09	0.37		2881	
1/29/02	East Road	11700	2.5	0.45	0.19	4875	1409
10/31/01	Main & Curved	1400	0.64	0.11		149	
11/8/01	Main & Curved	3000	1.99	0.36		995	
12/3/01	Main & Curved	2520	0.19	0.03		80	
12/13/01	Main & Curved	2600	0.6	0.11		260	
1/4/02	Main & Curved	1050	0.46	0.08		81	
1/16/02	Main & Curved	5970	1.22	0.22		1214	
1/29/02	Main & Curved	9400	0.74	0.13		1159	
1/29/02	Main & Curved	4230	0.66	0.12		465	
2/22/02	Main & Curved	333	0.1374	0.02	0.13	8	490
12/21/01	Station Street	19600	4.47	0.80		14602	
12/26/01	Station Street	9700	0.84	0.15		1358	
1/4/02	Station Street	3960	0.58	0.10		383	
1/11/02	Station Street	492	0.52	0.09		43	
1/16/02	Station Street	1640	0.74	0.13		202	
1/16/02	Station Street	1130	0.59	0.11		111	
11/5/01	Station Street	8000	1.63	0.29		2173	
11/13/01	Station Street	1050	0.41	0.07		72	
11/16/01	Station Street	14500	1.45	0.26		3504	
11/21/01	Station Street	588	0.09	0.02		9	
11/27/01	Station Street	3220	0.5	0.09	0.19	268	2066
12/13/01	Station & Main	3249	7	1.26		3791	
1/24/02	Station & Main	15700	1.2	0.22		3140	
2/28/02	Station & Main	15700	1.78	0.32	0.60	4658	3863
10/31/01	Truck Dump	776	6.35	1.14		821	
11/21/01	Truck Dump	4297	14.22	2.55		10184	
12/18/01	Truck Dump	1389	5.93	1.06		1373	
1/9/02	Truck Dump	41900	2.51	0.45		17528	
1/10/02	Truck Dump	9660	1.3	0.23		2093	
1/11/02	Truck Dump	12100	2.57	0.46		5183	
1/21/02	Truck Dump	12300	2.28	0.41		4674	
1/24/02	Truck Dump	1530	0.78	0.14		199	
2/22/02	Truck Dump	5710	0.4904	0.09		467	
2/28/02	Truck Dump	5710	0.1371	0.02	0.66	130	4265

Notes:
Only 44 of the 130 samples are shown here, because these were the only samples with reported sample weights.
Total sample area for all samples is 6 ft^2

Table A-5
Summary Statistics by Zone and Sample Location

Remed	Zone	Description	Location	Avg Pb for all dates	Max Pb for all dates	Min Pb for all dates	Number of samples
Post	A	Approaching Plant via Main St.	223 BROADWAY A	805	2600	180	11
Post	A	Approaching Plant via Main St.	223 BROADWAY B	821	2700	120	11
Post	A	Approaching Plant via Main St.	534 MAIN A	9030	23000	1200	10
Post	A	Approaching Plant via Main St.	543 MAIN B	34930	79000	5500	10
Post	B	Adjacent to Plant	East Road	6736	12200	1770	11
Post	B	Adjacent to Plant	Main & Curved	3005	9400	258	9
Post	B	Adjacent to Plant	MAIN & STATION A	20218	45000	3800	11
Post	B	Adjacent to Plant	MAIN & STATION B	44455	93000	18000	11
Post	B	Adjacent to Plant	MAIN @ MUNICIPAL PARK A	18045	60000	3600	11
Post	B	Adjacent to Plant	MAIN @ MUNICIPAL PARK B	44045	190000	9500	11
Post	B	Adjacent to Plant	Station & Main	12857	16900	3240	4
Post	B	Adjacent to Plant	Station Street	18900	255000	469	11
Post	C	Residential Area not on Haul Route	926 DALE A	1851	6400	210	11
Post	C	Residential Area not on Haul Route	926 DALE B	1984	6600	610	11
Post	C	Residential Area not on Haul Route	STATION & CROSS A	28864	120000	2300	11
Post	C	Residential Area not on Haul Route	STATION & CROSS B	14833	94000	470	11
Post	C	Residential Area not on Haul Route	STATION & CURVED A	12220	29000	3600	10
Post	C	Residential Area not on Haul Route	STATION & CURVED B	26390	56000	5900	10
Post	D	Haul Route Area	BROWN & JOACHIM A	11927	37000	2000	11
Post	D	Haul Route Area	BROWN & JOACHIM B	16536	36000	4600	11
Post	E	Remote Area	JOACHIM & 61-67 A	3673	8900	500	11
Post	E	Remote Area	JOACHIM & 61-67 B	6052	20000	670	11
Post	E	Remote Area	JOACHIM & BALLFIELD A	10773	26000	2800	11
Post	E	Remote Area	JOACHIM & BALLFIELD B	12300	39000	2300	11
Post	E	Remote Area	SCENIC @ CEMETERY A	593	1400	180	11
Post	E	Remote Area	SCENIC @ CEMETERY B	987	2800	320	11
Pre	F	Approaching Plant via Broadway	Intersect Reservoir and Broadway, on sidewalk	2860	2860	2860	1
Pre	G	Adjacent to Plant	Curved St, sidewalk, 100 yds west of plant	8300	8300	8300	1
Pre	G	Adjacent to Plant	Intersect. Station St and Broad St., 10 ft west, small pile	229000	229000	229000	1
Pre	G	Adjacent to Plant	Intersect. Station St and Broad St., small pile	294000	294000	294000	1
Pre	H	Residential Area not on Haul Route	Crain and Joachim Ave, east side	2060	2060	2060	1
Pre	H	Residential Area not on Haul Route	Crain and Joachim Ave, west side	1910	1910	1910	1
Pre	I	Haul Route Area	Across St from Amvets, City Park with boat ramp, soil in the lawn area	4260	4260	4260	1
Pre	I	Haul Route Area	Further west, Joachim Ave., next to pay fishing lake	38800	38800	38800	1
Pre	I	Haul Route Area	Intersect. Brown and Curved Streets, east side	175000	175000	175000	1
Pre	I	Haul Route Area	Intersect. Brown and Curved Streets, west side	67000	67000	67000	1
Pre	I	Haul Route Area	West of above, on Brown St, Next to Amvets Bldg	67500	67500	67500	1
Pre	J	Remote Area	Intersect Lake Dr and Commercial Blvd	3800	4000	3600	1
Pre	J	Remote Area	Intersect Scenic and Riverview	1100	1170	1030	1

Appendix B

Particulate Emissions Calculations

PM_{10} Emission Factor for Paved Roads (from AP-42):

$$E_{10} = 4.6\ (SL/2)^{0.65}\ (W/3)^{1.5}$$

where:

E_{10} = PM_{10} emission factor (g/VKT)
SL = silt loading (g/m^2)
W = average weight of vehicles (tons)
VKT = vehicle kilometers traveled

$$E_{10} = 4.6 * ((2/2)^{0.65}) * ((2.7/3)^{1.5})$$

$$E_{10} = 3.94 \text{ g / VKT } PM_{10}$$

$$E_{total} = 3.94 \text{ g/VKT} \times 1100 \text{ Vehicles/day}$$

$$E_{total} = 4331 \text{ g/km-day}$$

Assume road is 45 feet wide = 13.7m
Length 1 km = 1000m
Area per km = 1000m × 13.7m = 13,700 m^2/km

$$E_{total} = (4331 \text{ g/km-day})\ (1 \text{ km} / 13{,}700 \text{ m}^2)\ (1 \text{ day}/24 \text{ hr})\ (1 \text{ hr}/3600 \text{ sec})$$

$$E_{total} = 3.66\times10^{-6} \text{ g dust / m}^2\text{-sec as } PM_{10}$$

Average lead concentration in street dust (Zone B) = 20,254 mg Pb/kg dust

$$E_{Pb} = 7.41\times10^{-8} \text{ g Pb/m}^2\text{-sec}$$

Dispersion Factor from ISCST3 model = 1.02×10^{6} (µg Pb /m^3) / (g Pb /m^2-sec)

Annual Average Incremental Air Lead Concentration due to Particle Re-entrainment:

$$\text{Air Lead EPC} = E_{Pb} \times \text{Dispersion Factor}$$

$$\text{Air Lead EPC} = 0.076\ \mu\text{g Pb /m}^3$$

Table B-1
Particulate Emissions due to Particulate Re-entrainment from Vehicular Traffic on Paved Roads

Input	Description	Value	Units
SL	Silt loading on street	2	g/m^2
W	Avg vehicle weight	2.7	tons
NC	Number of cars	1050	cars/day
NT	Number of trucks	50	trucks/day
NV	Number of vehicles	1100	vehicles/day
WC	Weight of car	1.5	tons
WTf	Truck weight full	40	tons
WTe	Truck weight empty	16	tons
WT	Avg Weight of truck	28	tons
RL	Road length	1000	m
RW	Road width	13.7	m
A	Area per km	13,700	m^2/km
C	**Street Dust Pb Conc.**	**20,254**	**mg Pb /kg dust**

Calculated Emissions Rates			
E10	PM10 emission factor	3.94	g / VKT PM10
E total	PM10 emission factor	4331	g/ km-day
E total	PM10 emission factor	3.66E-06	g dust /m^2-sec
E Pb	Lead emissions rate	7.41E-08	g Pb /m^2-sec

From Previous ISCST3 Air Modeling:		
Calc Pb emission rate	3.18E-08	g Pb /m^2-sec
Calc max concentration at edge of road, north side	0.03257	µg Pb /m^3
Calc Dispersion Factor	1.02E+06	(µg Pb /m^3) / (g Pb /m^2-sec)

Air Lead EPC:		
Annual Average Incremental Air Lead Concentration due to Particle Re-entrainment (E_{Pb} x Disp. Factor)	**0.076**	**µg Pb /m^3**

Appendix C

Bioavailability Study

Final LABORATORY REPORT

For

Doe Run Company

November 16, 2001

By

Dr. John W. Drexler
Laboratory for Environmental and Geological Studies
University of Colorado
Boulder, CO. 80309
(303) 492-5251

INTRODUCTION

Four samples were sent to the laboratory for lead in vitro bioavailability. A representative split of each sample was collected for both analyses. Bioavailability results are listed in Table 1.

Three of the samples have very low relative bioavailabilities (RBA's). These low RBA's are consistent with materials that are 1) well slaged (lead is enclosed in glassy matrix or in glass structure itself 2) lead sulfide, based on previous speciation studies. The other sample (sinter composite) has moderately high relative bioavailability.

METHODS

INVITRO PROCEDURE

Bioavailabilty was conducted using the method developed at the University of Colorado, Boulder and calibrated to EPA's Region VIII Swine Model Medlin and Drexler, 1996, Medlin, 1997, Drexler, 1997. The method has a high level of correlation to the Swine Model for lead (r=0.96) however, at present the correlation for arsenic is not as good (r=0.76). Based on these data it is recommended that one interpret arsenic bioavailability results with greater caution.

The method follows a carefully designed laboratory SOP, which is available on request. The procedure uses 1.0 grams of the <250μm size fraction, this material is placed in 125ml wide-mouth HDPE bottles along with 100ml of 1.5 pH stomach solution. The mixture is rotated end-on-end at 37°C in a water bath for one hour. After one hour 10ml of sample is removed, filtered (0.45μm), and analyzed for lead and/or arsenic following Methods 6010B, 6020, or 7061A. Results from this extraction procedure are then used to calculated bioavailable lead and/or arsenic from the bulk <250μm concentrations.

PRECISION and ACCURACY

Quality assurance for the in vitro bioavailability procedure will consist of:

Regent Blank 1:10
Bottle Spike 1:20
Blank Spike 1:20
Duplicate Sample 1:10
Matrix Spikes 1:10
LCS 1:20

Control limits and corrective actions are described in the QAPP.

Sample population in this study was too small to evaluate QA.

TABLE 1. Summary Of In Vitro Bioassay Results for Doe Run

Sample Name	Batch #	Pb in bulk soil	mass soil (g)	calc Pb #1	ICP Pb (mg/l)	solution amt (l)	Relative Pb Bioavailability
BF-SLAG-COMP-COARSE		10059	1.0017	10.08	0.270	0.1	0.2
BF-SLAG-COMP-GROUND		20879	1.00502	20.98	2.495	0.1	1.2
PB-ORE-COMP		790000	1.02833	812.38	78.107	0.1	0.9
SINTER-COMP		345010	1.00512	346.78	2543.839	0.1	73.4
PB-ORE-COMP-Dup		790000	0.54951	434.11	45.078	0.1	1.0
SINTER-COMP-Dup		345010	0.37456	129.22	883.073	0.1	68.3

Laboratory of Environment and Geological Sciences, University of Colorad

Project Name: DOERUN-10-17-01-INVITRO

Run #: | Date: 10/23/01 | Operator: Drexler

Postion in rack	Sample name	Lab#	Wt. Grams	pH start	Starting time	Stopping time
1	BF-SLAG-COMP-COARSE		1.0017	1.556	8:40	9:40
2	BF-SLAG-COMP-GROUND		1.00502	1.556	8:40	9:40
3	PB-ORE-COMP		1.02833	1.556	8:40	9:40
4	SINTEN-COMP		1.00512	1.556	8:40	9:40
5						
6						
7						
8						
9						
10						

Project Name:

Run #: | Date: | Operator:

Postion in rack	Sample name	Lab#	Wt. Grams	pH start	Starting time	Stopping time
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Laboratory of Environment and Geological Sciences, University of Colorado, Boulder

Project Name: DOERUN-2

Run #: 2 Date: 11/9/01 Operater: drexler

Postion in rack	Sample name	Lab#	Wt. Grams	pH start	Starting time	Stopping time	pH stop
1	PB-ORE		0.54951	1.499	12;18	1:18	1.511
2	SINTER ORE		0.37455	1.499	12:18	1:18	1.614
3							
4							
5							
6							
7							
8							
9							
10							

Project Name:

Run #: Date: Operater:

Poction in rack	Sample name	Lab#	Wt. Grams	pH start	Starting time	Stopping time	pH stop
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Appendix D

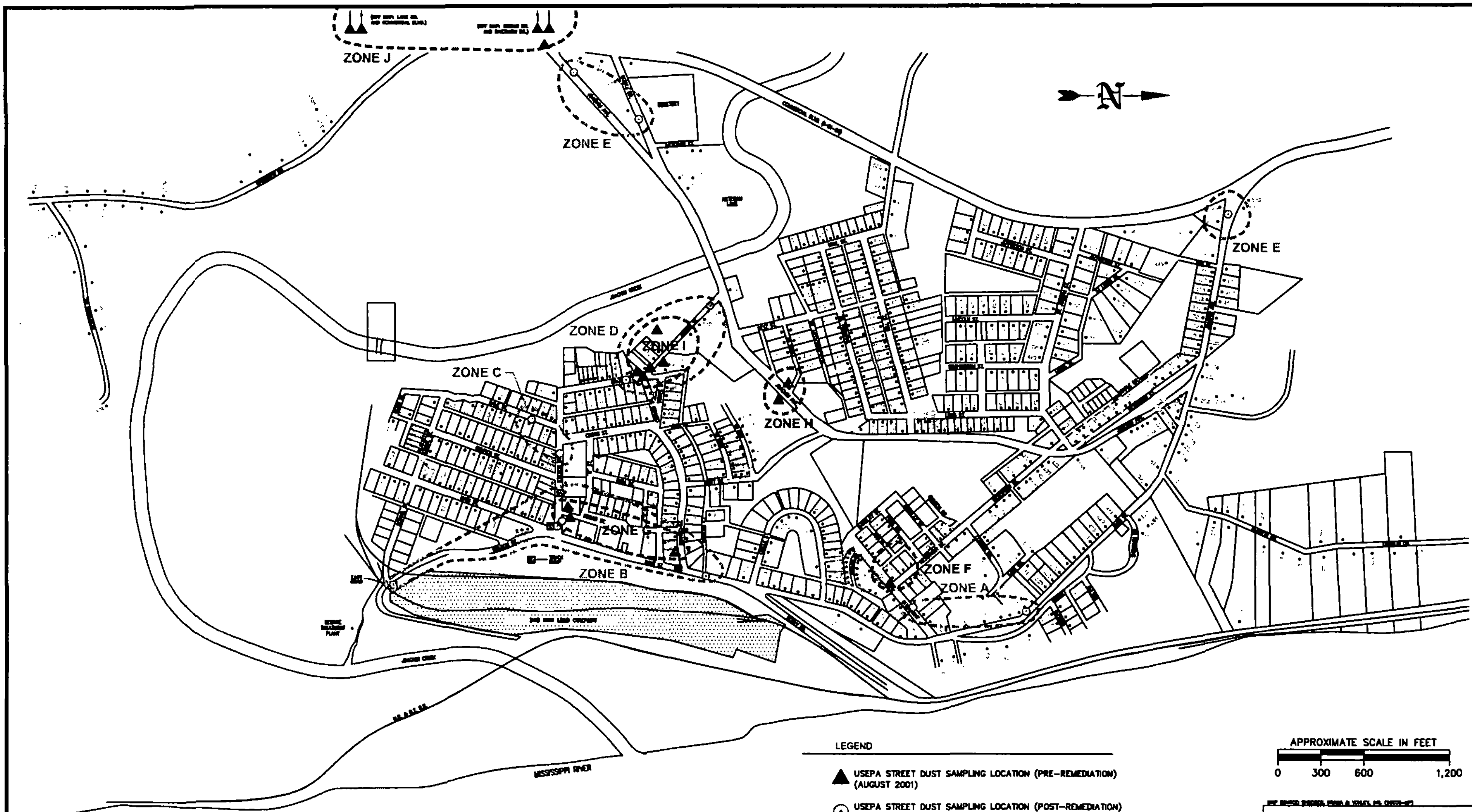
Biographical Sketches for Major Authors

Teresa S. Bowers, Ph.D.
Principal

Dr. Bowers is a modeling expert with over 18 years of experience in exposure modeling, mathematical and geochemical modeling, and the application of this information to the calculation of site-specific cleanup levels. She is the author of more than 30 journal articles on these and other topics. Her areas of expertise include modeling of blood lead and urine arsenic levels resulting from exposure to environmental sources of lead and arsenic. She is the author of an adult lead model now being used by EPA, and she has developed unique statistical approaches to calculating soil cleanup levels on average. Prior to joining Gradient, Dr. Bowers held research and visiting faculty positions at the Massachusetts Institute of Technology and Harvard University, where she taught courses in resource geology and applied thermodynamics. Dr. Bowers holds a Ph.D. in Geochemistry from the University of California, Berkeley, and undergraduate degrees in Mathematics and Geology from Purdue University.

Rosemary Mattuck, M.S.
Environmental Engineer

Ms. Mattuck is an environmental engineer specializing in human health risk assessments for heavy metals; blood lead modeling; geochemical modeling; contaminant fate and transport evaluations for hazardous waste sites; and litigation support for toxic tort, cost allocation, cost recovery, and product liability cases. She has managed numerous lead projects for industrial clients, provided regulatory comment for the lead industry, and authored several publications on lead exposure. At Gradient, her responsibilities include conducting and writing human health risk assessments, blood lead modeling, exposure modeling using analytical exposure models, statistical programming, and assisting in preparation of expert reports. Ms. Mattuck received an M.S. in Civil (Environmental) Engineering from University of Connecticut, and a B.A. in Chemistry from the University of Vermont.



LEGEND

- ▲ USEPA STREET DUST SAMPLING LOCATION (PRE-REMEDIATION) (AUGUST 2001)
- ⊙ USEPA STREET DUST SAMPLING LOCATION (POST-REMEDIATION) (OCT. 2001 – FEB. 2002)
- DOE RUN STREET DUST SAMPLING LOCATION (POST-REMEDIATION) (OCT. 2001 – FEB. 2002)
- EXPOSURE ZONE (PRE-REMEDIATION)
- EXPOSURE ZONE (POST-REMEDIATION)

APPROXIMATE SCALE IN FEET

0 300 600 1,200

Gradient CORPORATION

238 MAIN STREET • CAMBRIDGE, MA 02142 • (617) 395-5000

FIGURE 1

STREET DUST SAMPLING LOCATIONS

HERCULANEUM, MISSOURI

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